(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 January 2004 (22.01.2004)

PCT

(10) International Publication Number
WO 2004/006646 A2

(51) International Patent Classification[7]: A01D

(21) International Application Number: PCT/IL2003/000577

(22) International Filing Date: 13 July 2003 (13.07.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
150723 14 July 2002 (14.07.2002) IL

(71) Applicants and
(72) Inventors: **PODOLSKY, Boris** [IL/IL]; Wedgwood Av. 26g, 34635 Haifa (IL). **SADAN, Nir** [IL/IL]; Gan Ner 70, 19351 D.N. Gilboa (IL).

(74) Common Representative: **PODOLSKY, Boris**; Wedgwood Av. 26g, 34635 Haifa (IL).

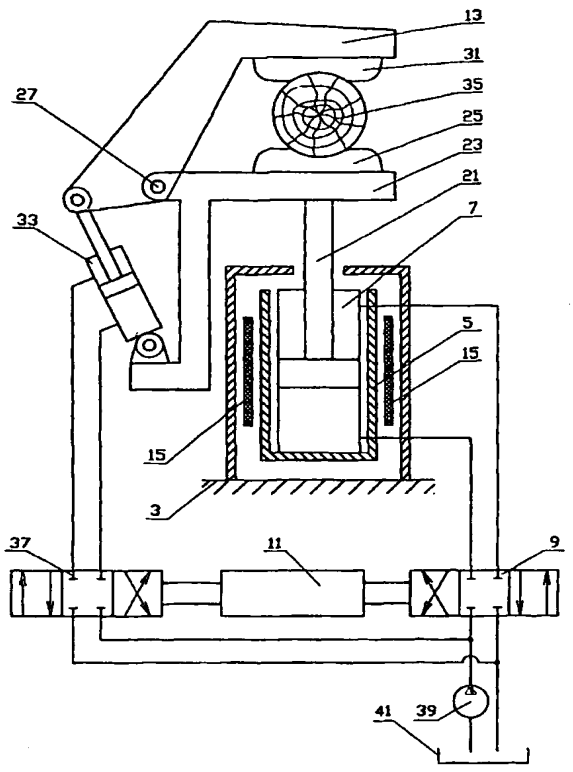
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MULTI-PURPOSE SHAKING METHOD AND APPARATUS FOR THE ORCHARD HARVESTING



(57) Abstract: The present invention relates to fruit- and nut-harvesting equipment, and more particularly to methods and apparatus for shaking fruit and nuts. There is suggested a multi-purpose shaking method for the orchard harvesting including bringing to a fruit tree or shrub a vehicle with a shaking apparatus mounted thereon. The claimed method is accomplished on the basis of a suggested device-multi-purpose shaking apparatus. This apparatus comprises: a frame mounted on the body of a vehicle, a housing which encloses a means for generating measured vibration and means for controlling measured vibratory action, controlled grip, counterweights and a controlled linkage suspension. The controlled grip of said shaking apparatus is mounted at the free end of the means for generating measured vibration and provided with a controlled driving means. The housing of the shaking apparatus is suspended on the frame via a controlled linkage suspension.

WO 2004/006646 A2

MULTI-PURPOSE SHAKING METHOD AND APPARATUS FOR THE ORCHARD HARVESTING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to fruit- and nut-harvesting equipment, and more particularly to methods and apparatus for shaking fruit and nuts from the limbs of trees and shrubbery.

2. Description of the Related Art

Most of the fruit- and nut-harvesting devices are mechanical devices, which typically operate by gripping the tree trunk and imparting thereto a controlled, low-frequency vibration or shaking action. This operation dislodges the fruit or nuts, which are then collected and transported.

A typical tree-shaking apparatus includes two opposing clamp members that engage the tree trunk, and which are themselves driven by dual oscillation

or vibration units. Bunnelle in U.S. Pat. 4,903,471 disclose a shaking method and apparatus – a variable force tree shaker, which includes a non-rotatable housing having a two-piece shaft journalled therein. A fixed weight is rigidly connected to the shaft and an adjustable weight is pivotally connected to the shaft. At least one hydraulic cylinder is formed in the fixed weight and receives a piston which is connected to the adjustable weight by a piston rod. While the shaft is driven, a hydraulic controller directs hydraulic fluid into said at least one piston which moves the adjustable weight between a balanced position diametrically opposed to the fixed weight providing no shaking forces to the shaft, and a plurality of unbalanced position imparting shaking forces of different intensities to the shaft.

Reynolds de Sousa et al. in U.S. Pat. 5,595,054 disclose a low power agrical mechanical tree shaker, using phase-controlled linear impact vibrations and including an adjustable springs set that connects the vibration set to the clamp/trunk or limb set through the guiding system and allows to set the spring tension for resonance vibration after attaching the shaker to a particular tree. Consequently, the vibration of the shaker set will have an adjustable phase angle between the shaker set and the clamp/trunk or limb set, between 0^0 and 360^0. The clamp has the form of a fork and includes a set of vulcanized asymmetric grips, a vulcanized chains set, for the attachment of the clamp to the tree.

Orlando in U.S. Pat. 4,893,459 discloses a variable force tree shaker, including a rotatable housing supporting a weight fixed to the housing and a movable weight, with the movable weight being capable of being moved between a balanced position and a plurality of unbalanced positions while the housing is rotating at a shaking speed. Hydraulic fluid is controllably directed into the housing between the fixed and movable weights to move the movable weight while the housing is rotating.

Pool et al. in U.S. Pat. 3,537,246 and 3,592,073 disclose a tree shaker apparatus including a frame pivotally mounted on a tractor for swinging movement about a vertical axis and a horizontal axis. A boom and clamp assembly is mounted on the frame for movement longitudinally thereof. Movement of the frame and the boom and clamp assembly is provided by hydraulic cylinders controlled through respective valves. The valves are actuated by selective operation of a control lever which is mounted for swinging movement in tree modes which are manifested in similar
movements of the frame and the boom and clamp assembly to position the clamp in gripping relation on a tree limb to be shaken by the apparatus.

Zehavi et al. in U.S. Pat. 5,473,875 disclose a tree-shaking apparatus that includes a pair of vibration units whose eccentric rotators turn at identical speeds but in opposite directions. During operation, rotation of the eccentric members is

coordinated by a controller such that their asymmetric portions align at two diametrically opposed points but lie precisely out of phase during the remainder of the rotation cycle. This action causes the tree to shake along a single axis, specified by the chosen alignment of the rotators, with vibratory forces along all other directions canceling out. A controller systematically alters the direction and frequency of shaking and monitors the resulting change in vibration amplitude, selecting, as a final shaking axis and frequency, those which correspond to the largest amplitude.

All aforesaid devices are similar in operation. The shaking action therein is performed substantially by exciting centrifugal vibrations of mechanical unbalance weights. The rotation of these unbalance weights generates a curved sinusoidal driving force which is not optimal for the dynamics of the process. In some existing devices it is possible to alter the
frequency or amplitude of driving force by altering the frequency of rotation of aforesaid unbalance weights and/or altering the excentricity of their mass.

At the same time, the existing devices have some major drawbacks, such as:

a) considerable difficulties in independent adjustment of frequency and amplitude of the driving force,

b) impossibility of adjusting the amplitude of actuator movement,

c) long transition processes at the beginning and end of vibration process,

d) impossibility of altering the curved driving force from a sinusoidal to any other,

e) impossibility of altering the curved driving force within each vibratory impulse and, as a result, impossibility of altering and optimizing the acceleration value.

An object of the present invention is to provide a multi-purpose shaking method and apparatus for the orchard harvesting by measured vibratory action on any parts (trunk, limbs, crown) of any fruit trees and shrubbery, and any other plants including of date-palm trees, nuts, olives etc.
irrespective of their dimensions and age, as well as dimensions and weight of fruits.

Another object of the invention is to provide selective collection of fruits according to predetermined parameters, such as ripeness stage of these

fruits, irrespective of their size or weight and irrespective of the kind, age and dimensions of trees or shrubbery wherein they grow.

SUMMARY OF THE INVENTION

Aforesaid objects of the invention may be achieved, in the inventors' opinion, by utilizing the claimed invention, including a multi-purpose shaking method and apparatus for the orchard harvesting.

The multi-purpose shaking method for the orchard harvesting includes bringing to a fruit tree or shrub a vehicle with a shaking apparatus mounted thereon, this apparatus having a controlled grip for a trunk, limbs or crown, with a means for exciting measured vibration, as well as with a means for controlling the measured vibratory action, as well as fixing the controlled grip the desirable portion of a trunk, limb or crown.

Then in the shaking apparatus there is generated a measured vibration transmitted via the controlled grip to a corresponding portion of this trunk, limb or crown of a corresponding fruit tree or trunk of a corresponding tree or shrub. For this purpose, there is performed, via the means for controlling

measured vibratory action, before the beginning of vibratory action or directly in the course of this vibratory action, stepwise or continuous adjustment of amplitude of movements of said controlled grip, as well as of frequency and any

other parameters of vibrations of the means for generating measured vibration. Thereby the vibration process is optimized both at any moment of its duration, and within each separate vibratory impulse, there are provided increase, reduction or change, according to a given program, in amplitude and frequency of these vibrations, as well as of any other vibration parameters. This permits to selectively collect fruits according to their ripeness stage, irrespective of size or weight of these fruits and irrespective of the kind, age and dimensions of trees and shrubbery wherein they grow.

To accomplish the claimed method, the means for generating measured vibration and the means for controlling measured vibratory action may be substantially hydraulic, pneumatic or electric. The method may be as well accomplished on the basis of these means when one of these means is hydraulic or pneumatic, and the other electric.

The claimed method is carried out on the basis of suggested multi-purpose shaking apparatus for the orchard harvesting by measured vibratory action on any parts (trunk, limbs, and crown) of any fruit trees and shrubbery,
and any other plants including of date-palm trees, nuts, olives etc. irrespective of their dimensions and age, as well as dimensions and weight of fruits. This apparatus comprises a frame mounted on the body of a vehicle, a housing

enclosing a means for generating measured vibration and a means for controlling measured vibratory action, controlled grip, counterweights and controlled linkage suspension. The controlled grip of shaking apparatus is mounted at the free end of aforesaid means for generating measured vibration and provided with a controlled driving means. The counterweights are substantially shaped as weights movably mounted in the housing to create a dynamic reaction of shaking apparatus. The housing of multi-purpose shaking apparatus is suspended on the frame via a controlled linkage suspension intended to prevent vibration transmission to the body of the vehicle.

The means for measured vibration may be a single rod, double rod or diaphragm hydraulic cylinder.

The means for controlling measured vibratory action of shaking apparatus is substantially a hydraulic control valve provided with a master

controller. This master controller may be substantially hydraulic, pneumatic or electric. It may have a programmed device, such as a microprocessor.

The controlled grip of shaking apparatus mounted at the free end of means for generating measured vibration is provided with a controlled driving means, such as a hydraulic cylinder. This hydraulic cylinder may be associated with the master controller.

The controlled linkage suspension whereby the housing is suspended on the frame is provided with at least one actuator formed substantially as a hydraulic cylinder. This hydraulic cylinder may be also connected to the master controller.

According to the claimed method the multi-purpose shaking apparatus may further have a pneumatic or electric drive or a combined hydro-electric or pneumo-electric drive, but these embodiments are not described in more detail herein, and the inventors decided at this stage to restrict themselves to a more detailed description of a multi-purpose shaking apparatus substantially with a hydraulic drive.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in conjunction with the following drawings FIG. 1 - 5 in which like reference numerals designate like elements and wherein:

FIG. 1 shows the basic diagram of the claimed apparatus wherein the means for generating measured vibration comprises a single rod hydraulic cylinder;

FIG. 2 shows a basic diagram of the claimed apparatus wherein the means for generating measured vibration is a double rod hydraulic cylinder;

FIG. 3 shows a diagram of the claimed apparatus with a housing suspended via linkage suspension on the frame mounted on a vehicle;

FIG. 4 – 5 show a diagram of the claimed apparatus with its housing suspended via linkage suspension on the frame secured on the vehicle, respectively at the initial (FIG. 4) and final (FIG. 5) moment of vibration cycle.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The claimed multi-purpose shaking apparatus for the orchard harvesting (see FIG. 1 - 3) comprises the following main parts: frame **1** secured on the body

of a vehicle **3**, housing **5** enclosing a means for generating measured vibration-single rod hydraulic cylinder 7 and means for controlling measured vibratory action containing a hydraulic control valve **9** and master controller **11**, as well as a set **13** of a control grip, counterweights **15** and controlled linkage suspension formed of rockers **17** and **19** (see FIG. 3).

Hydraulic cylinder **7** has a rod **21** (see FIG. 1) at the free end whereof there is mounted an arm **23** with cushion **25**. On the arm **23** there is secured, via pin **27**, a controlled grip **29** with cushion **31**. Controlled grip **29** is provided with a controlled driving means – hydraulic cylinder **33** and is capable of clamping or releasing the trunk or limb of a tree **35**. Hydraulic control valve **9**, such as a spool valve, is capable of delivering hydraulic fluid to hydraulic cylinder 7, and hydraulic control valve **37** – of delivering hydraulic fluid to hydraulic cylinder **33**. Both hydraulic control valves **9** and **37** are operated by master controller **11**. As master controller **11** there may be used a device of any type – mechanic, hydraulic, pneumatic, electric etc. In this case, there is applied substantially an electric master controller which may be programmed. Hydraulic pump **39** delivers hydraulic fluid under pressure from tank **41** to hydraulic control valves **9** and **37**.

FIG. 2 shows a diagram of another embodiment of the claimed apparatus wherein the means for generating measured vibration comprises a double rod hydraulic cylinder **43** with two rods **45** and **47** enclosed in housing **49.** The free end of rod **45** of hydraulic cylinder **43** (see FIG. 2) carries an arm **23** with cushion **25.** On the arm **23** there is secured, via pin **27,** a controlled grip **29** with cushion **31.** Controlled grip **29** is provided with a controlled driving means– hydraulic cylinder **33** and is adapted to clamp or release the trunk or limb of a tree **35.** Rods **45** and **47** are secured to piston **51** on its both ends. At the free end of rod **47** there is secured a clutch **53** which is, in turn, connected to hydraulic motor **55.** Clutch **53** is adapted to transmit certain angular movement from hydraulic motor **55** via rod **47,** piston **51** and rod **45** to arm **23** with grip **29,** which makes it possible to accommodate the grip to the inclination of the trunk or limb of a tree **35.**

Clutch **53** provides reciprocal movement of rod **47** relative to hydraulic motor **55** and housing **49.**

FIG. 3 shows the attachment of housing **49** of the claimed apparatus onto the chassis of a vehicle (tractor, automobile or any other self-propelled or pull-type vehicle) via a controlled linkage suspension. Housing **49** is suspended via rockers **17** and **19** on frame **57** attached to chassis **59** of the vehicle (the chassis is not shown in the drawings in detail). On the frame **57** there are also mounted

hydraulic cylinders **61** and **63** which, by their rods 65 and **67** respectively, fix rockers **17** and **19** to prevent their free vibrations relative to frame **57** at the moment, when the apparatus approaches the trunk or limb of a tree **35** or at the moment of clamping this trunk or limb **35** by grip **29**.

Counterweights **15** (see FIG.1) are substantially weights movably mounted in housing **5** to generate a dynamic reaction of the shaking apparatus.

The means for generating measured vibration may comprise a single rod hydraulic cylinder **7** (see FIG.1), double rod hydraulic cylinder **43** (see FIG. 2) or diaphragm hydraulic cylinder (not shown in the drawings).

The means for controlling measured vibratory action of shaking apparatus is substantially a hydraulic control valve **9** provided with a master controller **11** (see FIG. 1). This master controller **11** may be hydraulic, pneumatic or electric. In the described embodiment of the claimed apparatus, master controller **11** is electric and provided with a programmed device, such as microprocessor (not shown in the drawings). In the claimed apparatus master controller **11** also controls the operation of hydraulic control valve **37** hydraulic cylinders 33 and the operation of hydraulic cylinders **61** and **63** fixing the rockers **17** and **19** of linkage suspension.

The claimed apparatus operates as follows (see FIG. 4, 5).

Vehicle **59** with frame **57** mounted on its body approaches the tree. Rockers **17** and **19** of the linkage suspension are rigidly fixed by rods **65** and **67** of hydraulic cylinders **61** and **63**. On command from master controller **11**, hydraulic control valve **37** delivers hydraulic fluid to hydraulic cylinder **33** of grip **29**, the latter clamps the trunk or limb of a tree **35** between cushions **25** and **31**, to avoid damage to the trunk or limb of tree **35**. Clutch **53** and hydraulic motor **55** transmit a certain angular movement from hydraulic motor **55** via rod **47**, piston **51** and rod **45** to the arm **23** with grip
29 to turn them through a certain angle about the longitudinal axis and thereby accommodate the grip **29** to the inclination of the trunk or limb of tree **35**.

Then, on command from master controller **11**, rods **65** and **67** move inside hydraulic cylinders **61** and **63** to release rockers **17** and **19** of the linkage suspension on which housing **5** (see FIG. 1) or **49** (see FIG. 2) is suspended, so that this housing can freely vibrate relative to frame **57** and chassis **59**. Next, on command from master controller **11** hydraulic control valve **9** provides intermittent delivery of hydraulic fluid to hydraulic cylinder **7** or **43** (see FIG. 1 , 2), controlling thereby the vibrations of its piston **51**. FIG. 4 shows the movement of piston **51** to the right, while housing **49** moves to the left (due to

the reaction caused by pressure of hydraulic fluid in the hydraulic cylinder). FIG. 5 shows the movement of piston **51** to the left, while the housing **49** moves to the right. Counterweights **15** (see FIG.1) are weights movably mounted in body **5** or **49** to cause a dynamic reaction of the shaking apparatus.

The application of suggested apparatus for accomplishing the claimed method allows to adjust within a wide range and at any moment desired all the parameters of vibrations driving force both during the entire vibratory process, and within each vibration impulse. Besides, it is possible to adjust within a sufficiently wide range the amplitude of the actuator movements. The results of parameters alteration in the process of vibration of the actuator permit to provide maximum accelerations within each impulse and optimize the vibratory process. The absence of transition processes makes it possible to instantly start or stop the apparatus. Moreover, the optimization of vibratory process raises the percentage of fruit collection and reduces power demand, weight and cost of the apparatus.

The application of the claimed method and apparatus allows, in the opinion of the inventors, to solve the problem of selective harvesting in the orchard by measured vibratory action on any parts (trunk, limbs, crown) of any fruit trees and shrubbery, and any others plants including of date-palm trees,

nuts, olives etc. irrespective of their dimensions and age, as well as dimensions and weight of fruits.

Besides, in the opinion of inventors, it is also possible to provide selective harvesting of fruits according to predetermined parameters, such as ripeness stage of these fruits, irrespective of their size or weight and irrespective of the kind, age and dimensions trees or shrubbery.

While this invention has been described in conjunction with specific embodiment thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the preferred embodiments of the invention as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

We claim:

1. A multi-purpose shaking method for the orchard harvesting by means of measured vibratory action on any parts (trunk, limbs, crown) of any fruit trees and shrubbery, and any other plants including of date-palm trees, nuts, olives, etc. irrespective of their dimensions and age, as well as dimensions and weight of fruits, the method comprising:

i) bringing to a fruit tree or shrub a vehicle with a shaking apparatus mounted thereon, the apparatus having a controlled grip for the trunk, limbs or crown, a means for generating measured vibration, as well as a means for controlling the measured vibratory action;

ii) fixing the controlled grip on the required portion of a trunk, limb or crown;

iii) generating in the shaking apparatus a measured vibration transmitted via the controlled grip to the corresponding portion of the trunk, limb or crown of a corresponding fruit tree or trunk of a corresponding tree or shrub;

iv) stepwise or continuous adjustment, both before the beginning of vibratory action, and directly during vibratory action, via said means for controlling the measured vibratory action, of the

amplitude of movements of said controlled grip, as well as of frequency and any other parameters of vibrations of said means for generating measured vibration, to optimize the vibratory process both at any moment of its duration, and within each separate vibratory impulse, to raise, reduce or alter according to a predetermined program the amplitude and frequency of said vibrations, as well as any other parameters of vibrations,

whereby there is provided a possibility of selective harvesting of fruits according to their ripeness stage, irrespective of size and weight of these fruits and irrespective of the kind, age and dimensions of trees and shrubs wherein they grow.

2. A method for the orchard harvesting according to claim 1, wherein there are used said means for generating measured vibration, and said means for controlling the measured vibratory action, these means being substantially hydraulic.

3. A method for the orchard harvesting according to claim 1, wherein there are used said means for generating measured vibration, as well as said means for controlling measured vibratory action, these means being substantially pneumatic.

4. A method for the orchard harvesting according to claim 1, wherein there are used said means for generating measured vibration, as well as said means for controlling the measured vibratory action, these means being substantially electric.

5. A method for the orchard harvesting according to claim 1, wherein there are used said means for generating measured vibration, as well as said means for controlling measured vibratory action, one of these means being hydraulic or pneumatic and the other electric.

6. A multi-purpose shaking apparatus for the orchard harvesting by measured vibratory action on any parts (trunk, limbs, crown) of any fruit trees and shrubbery, and any other plants including of date-palm trees, nuts, olives etc. irrespective of their dimensions and age, as well as dimensions and weight of fruits, this apparatus comprising:

a) a frame mounted on the body of a vehicle;

b) a housing enclosing a means for generating measured vibration and means for controlling the measured vibratory action of said shaking apparatus;

c) a controlled grip of the shaking apparatus mounted at the free end of said means for generating measured vibration and having a controlled driving means;

d) counterweights, substantially weights movably mounted in the housing and intended for generating a dynamic reaction of shaking apparatus;

e) a controlled linkage suspension whereby said housing is suspended on said frame to avoid transmitting vibration to the body of a vehicle.

7. A multi-purpose shaking apparatus according to claim 6, wherein said means for generating measured vibration is substantially formed as a hydraulic cylinder.

8. A multi-purpose shaking apparatus according to claim 7, wherein said hydraulic cylinder is a single rod cylinder.

9. A multi-purpose shaking apparatus according to claim 7, wherein said hydraulic cylinder is a double rod cylinder.

10. A multi-purpose shaking apparatus according to claim 7, wherein said hydraulic cylinder is a diaphragm cylinder.

11. A multi-purpose shaking apparatus according to claim 6, wherein said means for controlling measured vibratory action of the shaking apparatus is substantially formed as a hydraulic control valve provided with a master controller.

12. A multi-purpose shaking apparatus according to claim 11, wherein said master controller is substantially hydraulic.

13. A multi-purpose vibratory apparatus according to claim 11, wherein said master controller is substantially pneumatic.

14. A multi-purpose shaking apparatus according to claim 11, wherein said master controller is substantially electric.

15. A multi-purpose shaking apparatus according to claim 14, wherein said master controller is provided with a programmed device, such as microprocessor.

16. A multi-purpose shaking apparatus according to claim 6, wherein the controlled grip of said shaking apparatus mounted at the free end of said means for generating measured vibration is provided with a controlled driving means, such as a hydraulic cylinder.

17. A multi-purpose shaking apparatus according to claim 16, wherein the controlled grip of said shaking apparatus mounted at the free end of said means for generating measured vibration is provided with a controlled driving means, such as hydraulic cylinder associated with said master controller.

18. A multi-purpose shaking apparatus according to claim 6, wherein said controlled linkage suspension whereby said housing is suspended on said frame is provided at least with one actuator formed substantially as a hydraulic cylinder.

19. A multi-purpose shaking apparatus according to claim 18, wherein said controlled linkage suspension is provided at least with one actuator formed substantially as a hydraulic cylinder associated with said master controller.

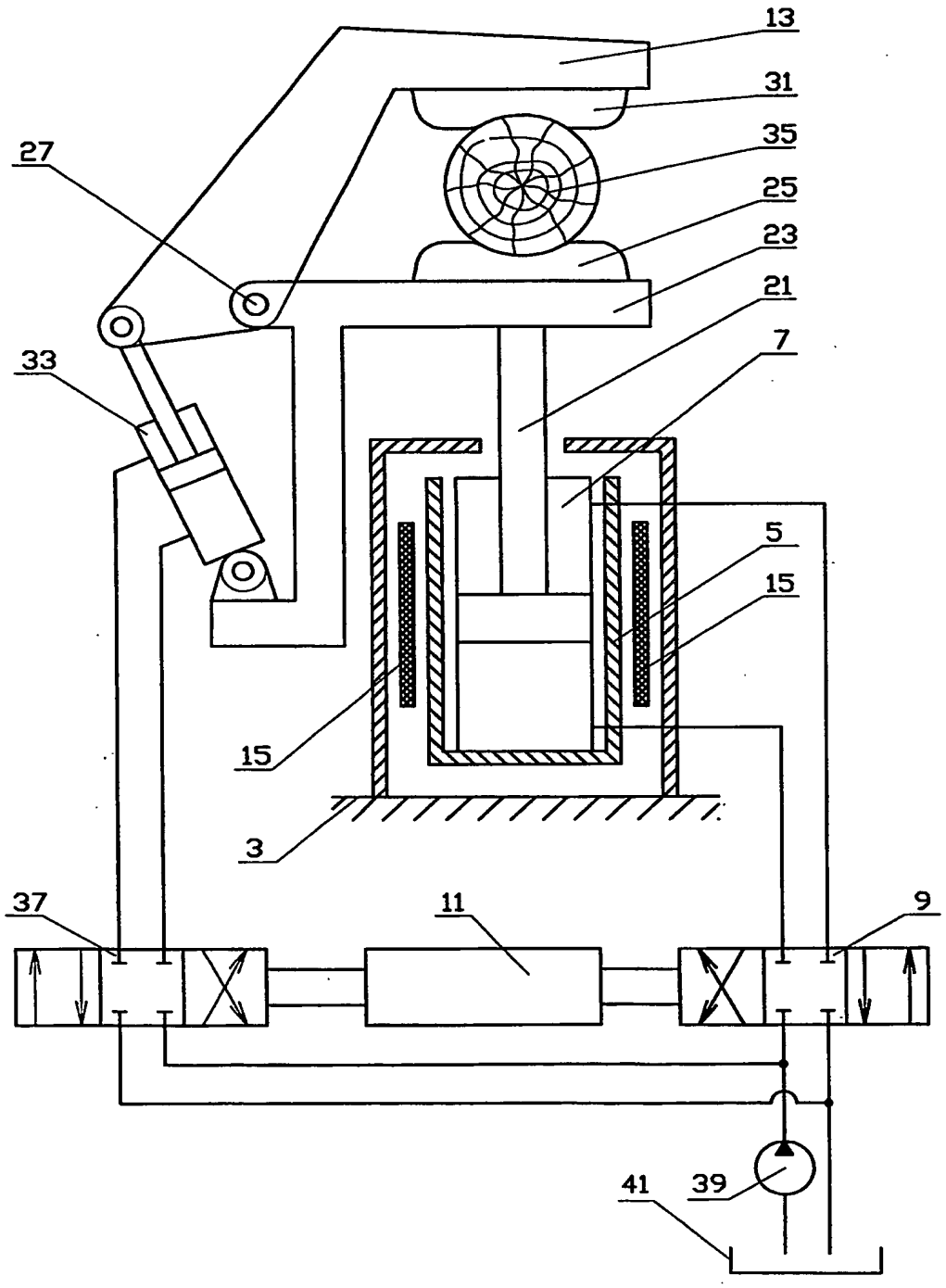


FIG.1

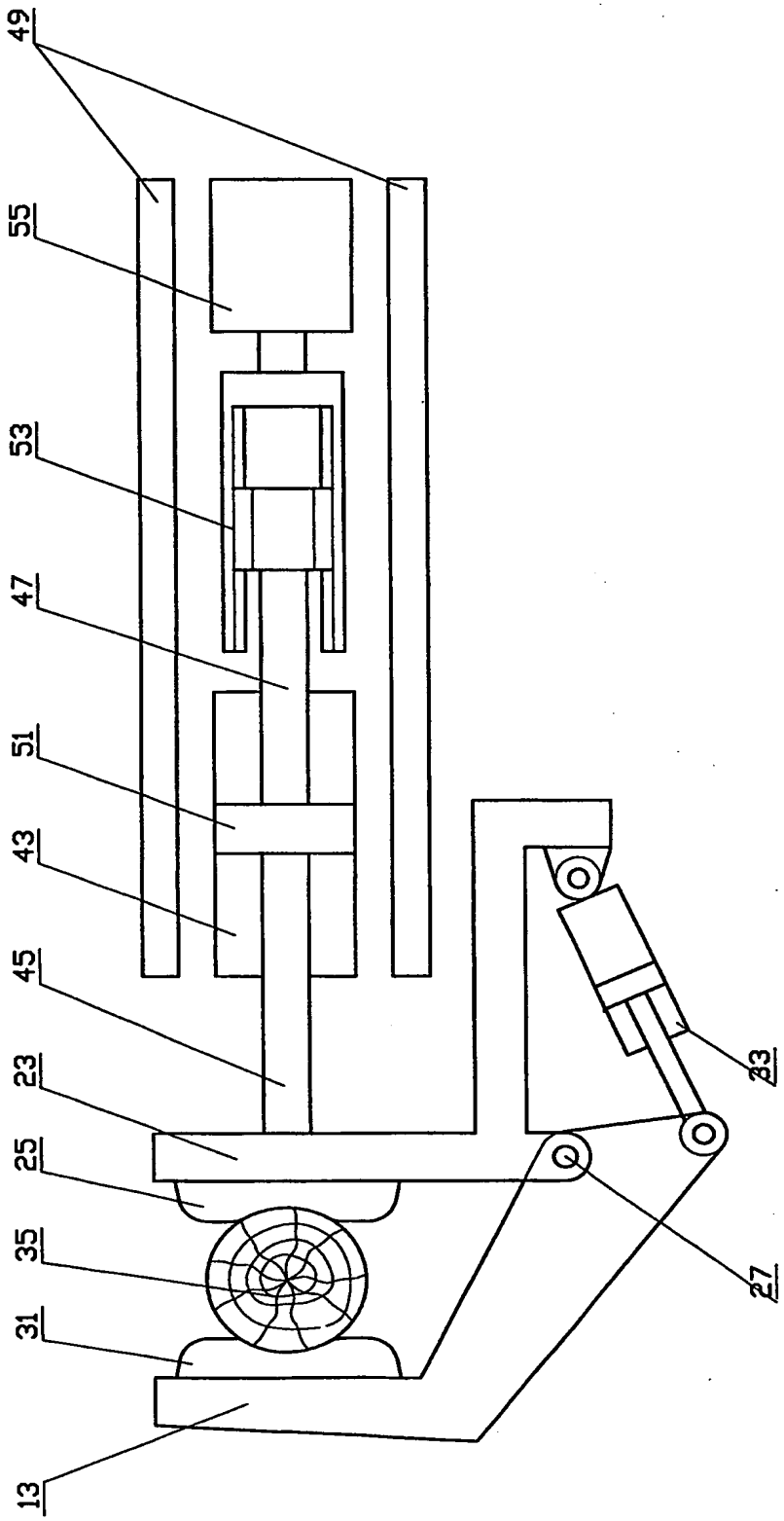


FIG.2

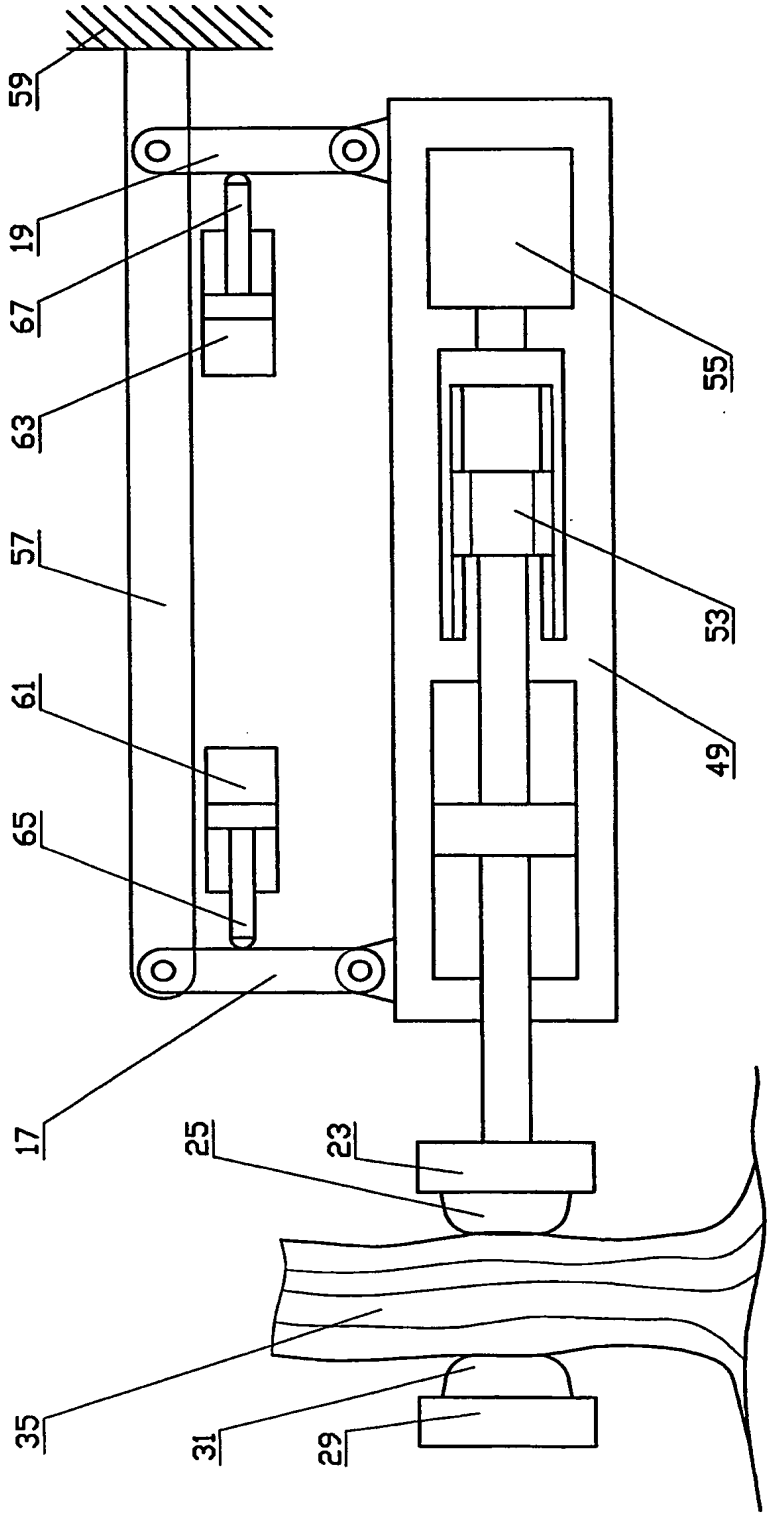


FIG3

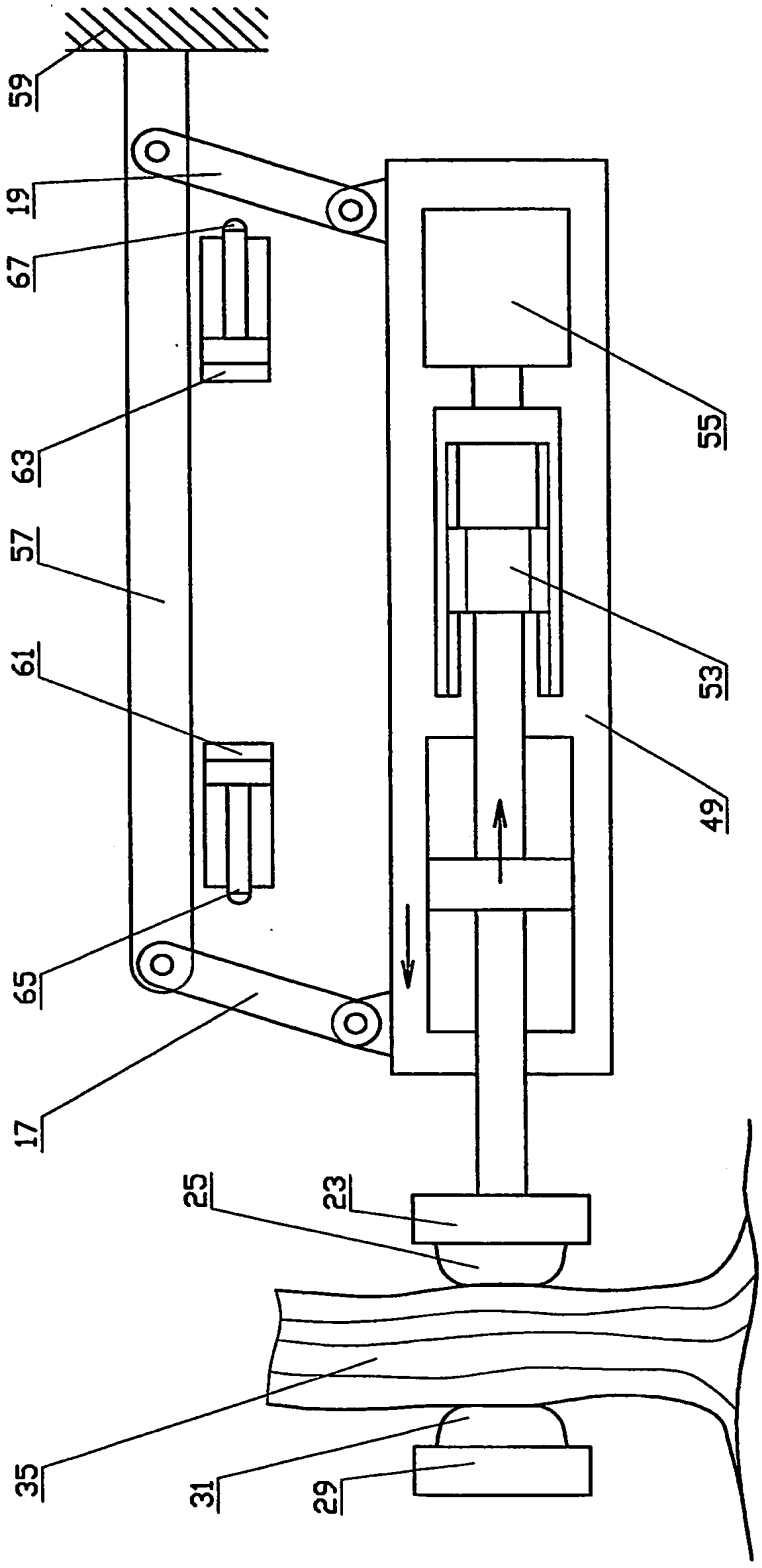


FIG4

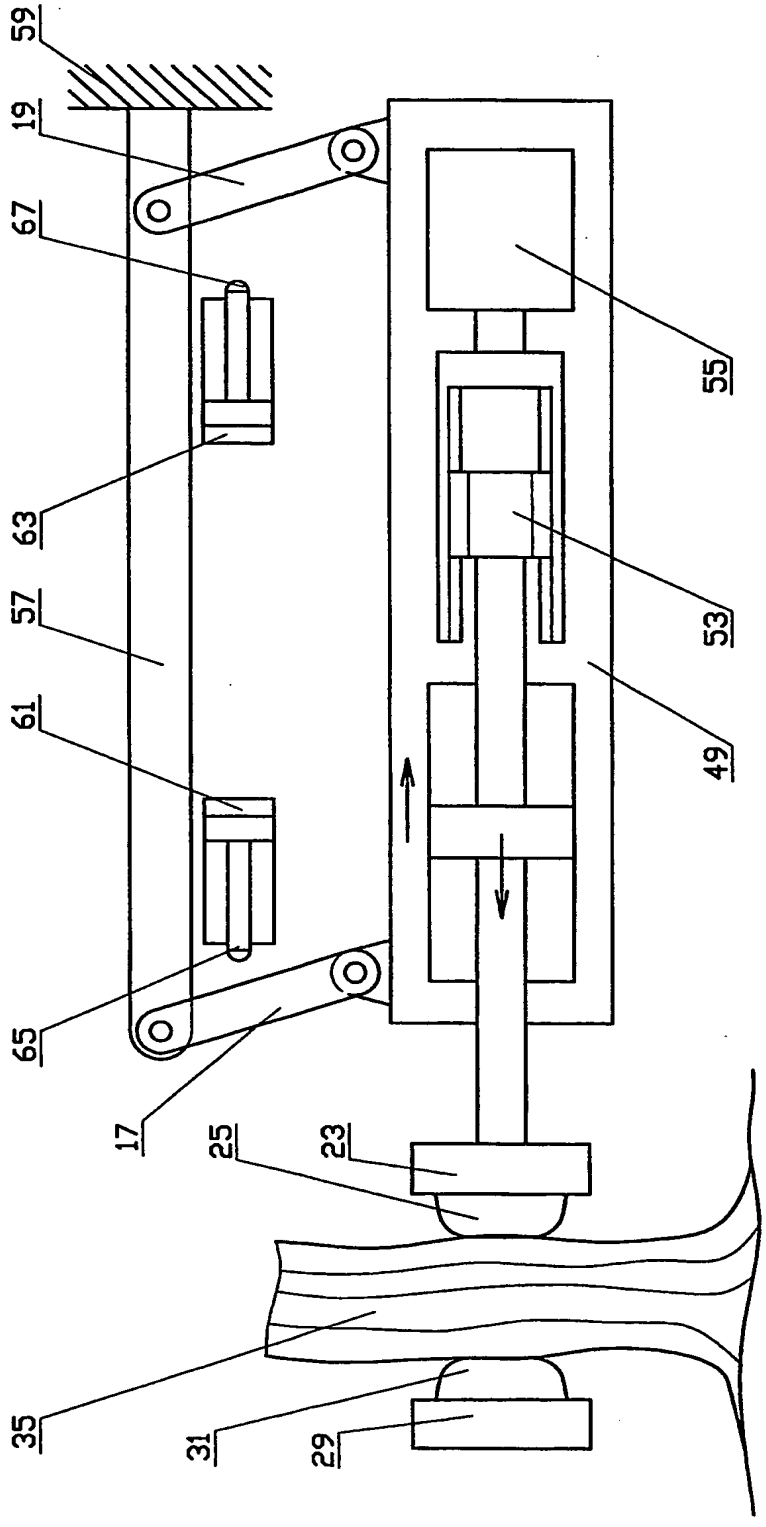


FIG5